

DØ Experiment and BNL

presented by

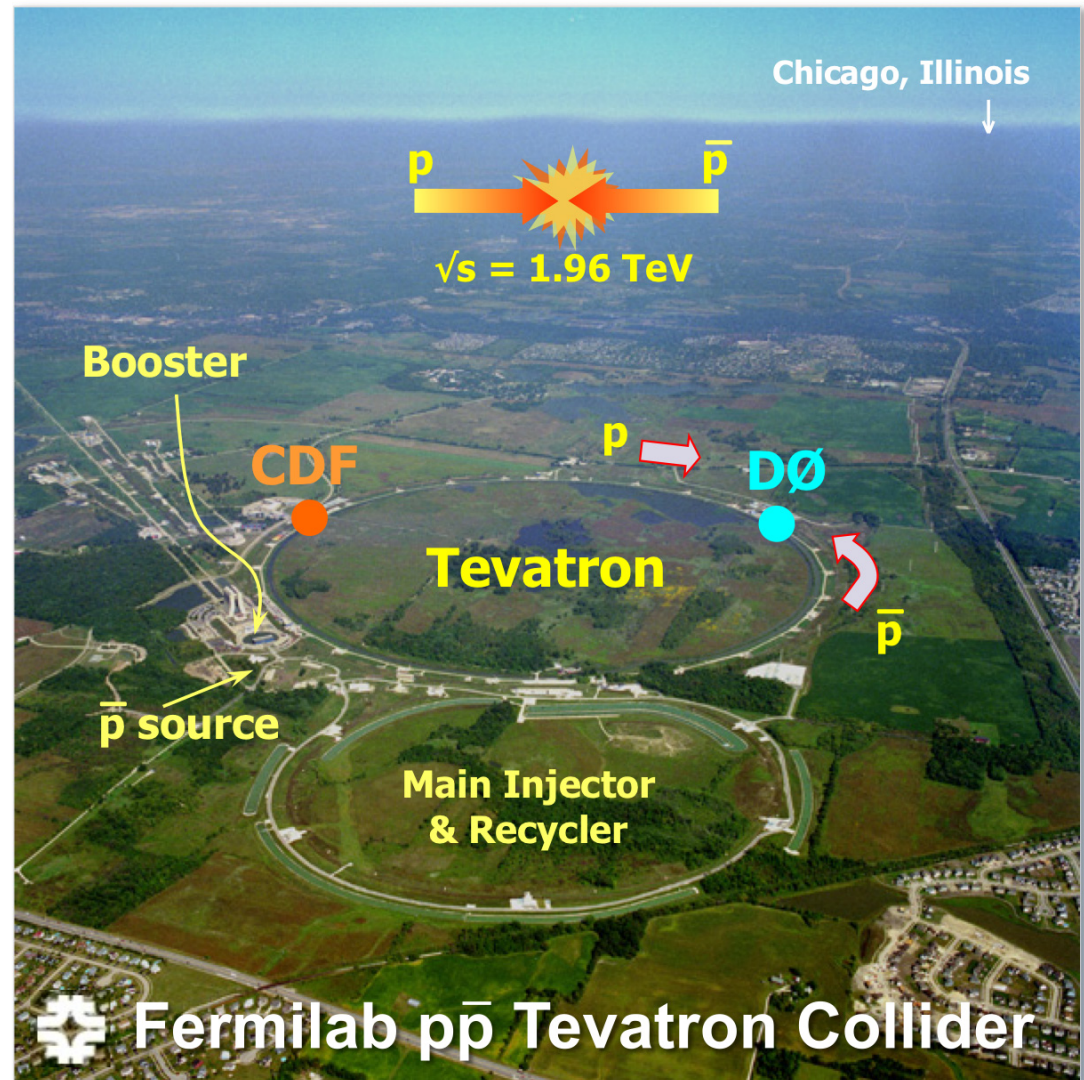
Abid Patwa

(for the DØ BNL Group)

*Department of Energy Review
September 8, 2009*



- ❖ **Overview of Results from DØ Experiment**
- ❖ **BNL-DØ Personnel**
- ❖ **Major BNL Contributions**
- ❖ **Present Status and Physics Results**
- ❖ **Closing Summary**





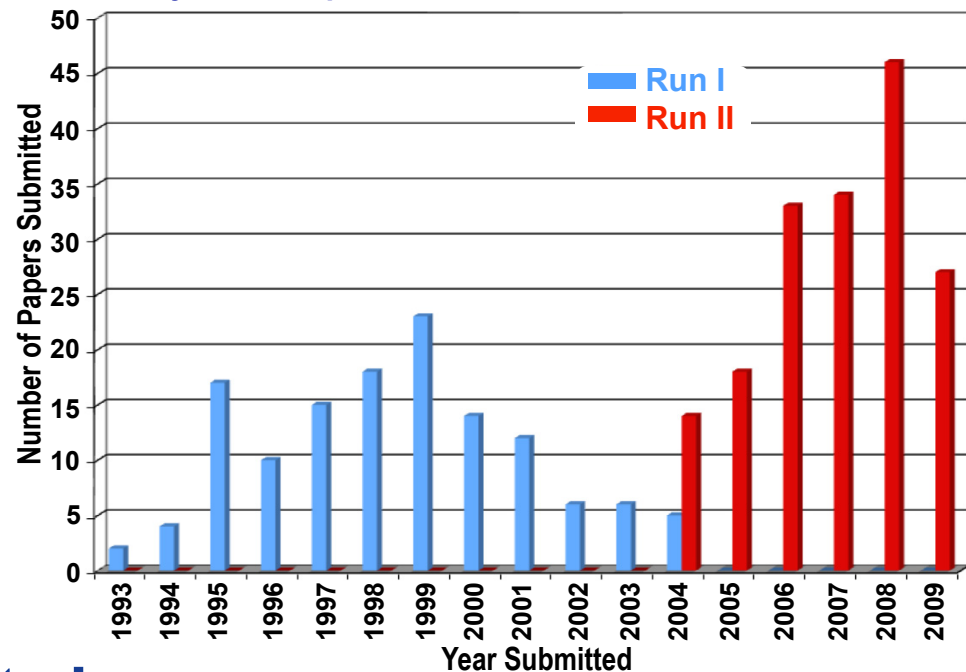
❖ Run II (2002-present) publications

- 163 publications accepted, additional 12 submitted

❖ On average, new paper published every week in 2009

- results across all physics areas
- past year, BNL-DØ group co-authored or reviewed 15 papers

History of DØ Paper Submissions to Peer-Reviewed Journals



❖ DØ Preliminary Results presented at major conferences — with BNL involvement, since ICHEP '08

- “Search for the SM Higgs boson in $\tau\tau q\bar{q}$ final state” 4.9 fb^{-1}
- “Search for assoc. prod. of b-quark and neutral Higgs decaying to τ 's” 2.7 fb^{-1}
- “Combined upper limits on MSSM Higgs boson” $1\text{-}2.6 \text{ fb}^{-1}$
- “Model Ind. Search for new physics at DØ in final states with leptons” 1.0 fb^{-1}
- “Combination of DØ top quark mass measurements” $0.1\text{-}3.6 \text{ fb}^{-1}$
- “Measurement of dijet mass cross section in $p\bar{p}$ coll. at $\sqrt{s}=1.96 \text{ TeV}$ ” 0.7 fb^{-1}



Fermilab Press Releases on DØ Results in 2009

Observation of Single Top Quark

DØ Single Top Results (2.3 fb⁻¹)

Analysis Method	Single top Cross Section	Significance Exp.	Obs.
Boosted Decision Trees	3.74 ^{+0.95} _{-0.79} pb	4.3 σ	4.6 σ
Bayesian Neural Nets	4.70 ^{+1.18} _{-0.93} pb	4.1 σ	5.4 σ
Matrix Elements	4.30 ^{+0.99} _{-1.20} pb	4.1 σ	4.9 σ
Combination	3.94 ± 0.88 pb	4.5 σ	5.0 σ

Published 8/28/09: PRL 103, 092001 (2009)

SM Higgs Exclusion: 160-170 GeV (95% CL)

Search for the Higgs Particle

(L = 0.9 – 4.2 fb⁻¹)

Status as of March 2009

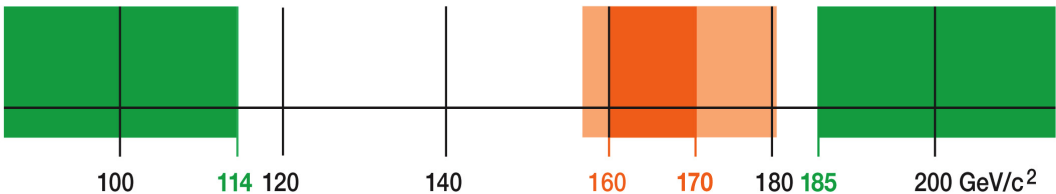
90% confidence level

95% confidence level

Excluded by
LEP Experiments
95% confidence level

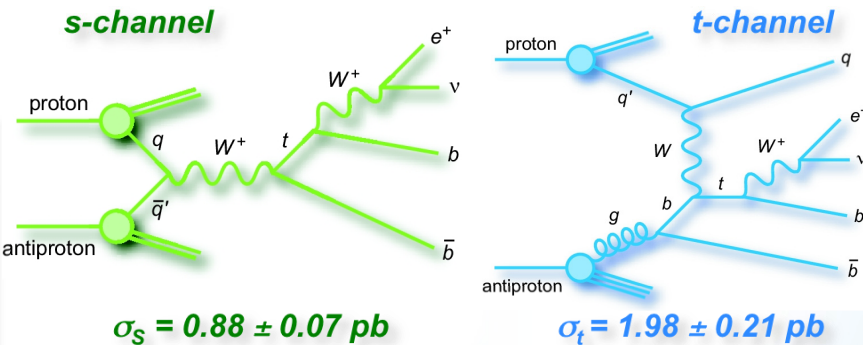
Excluded by
Tevatron
Experiments

Excluded by
Indirect Measurements
95% confidence level



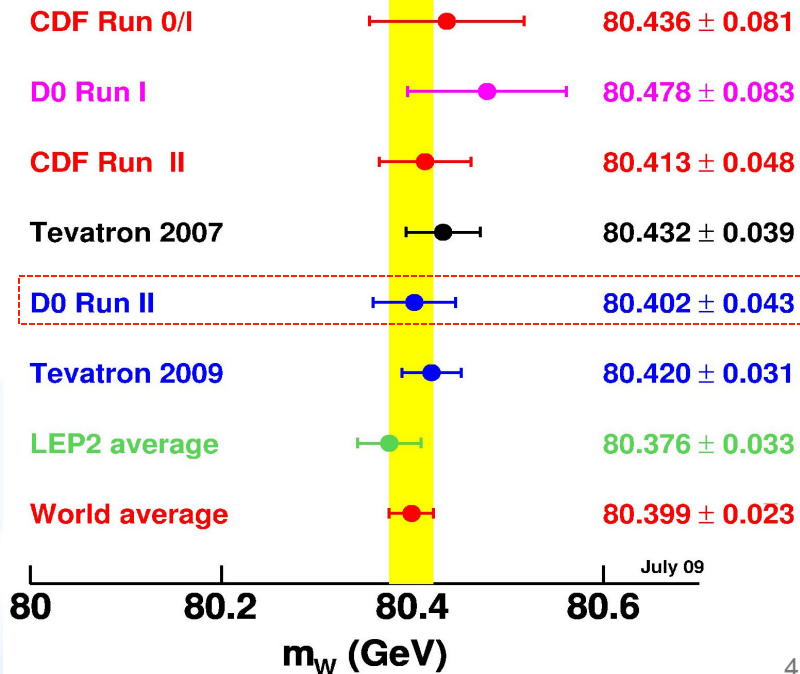
Ref: arXiv:0903.4001

Higgs mass values



World Best W Mass Measurement

DØ 1.0 fb⁻¹: Submitted to PRL



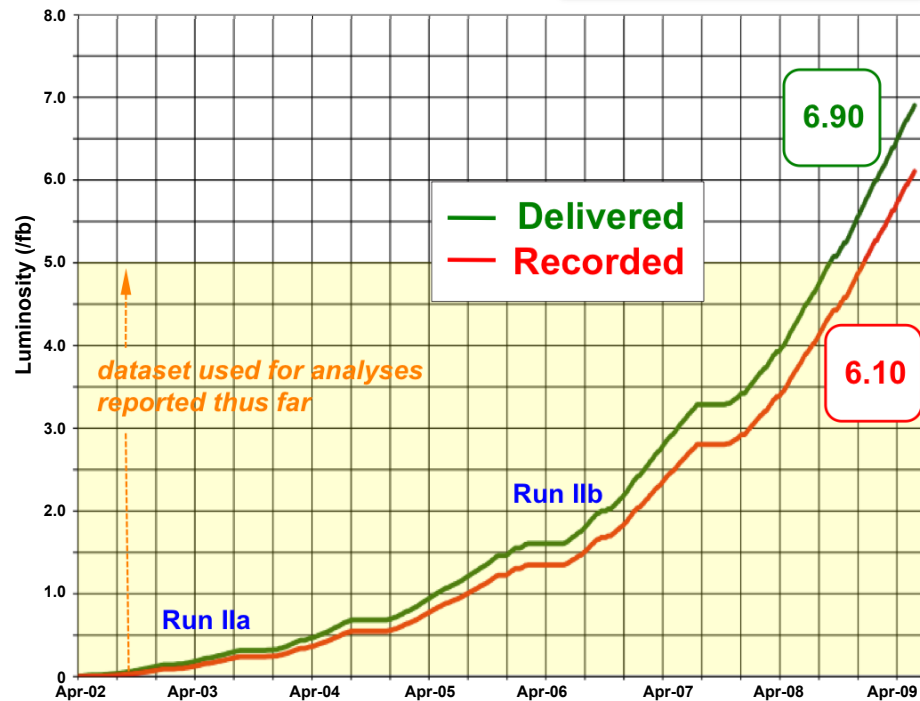


Tevatron and DØ Performance



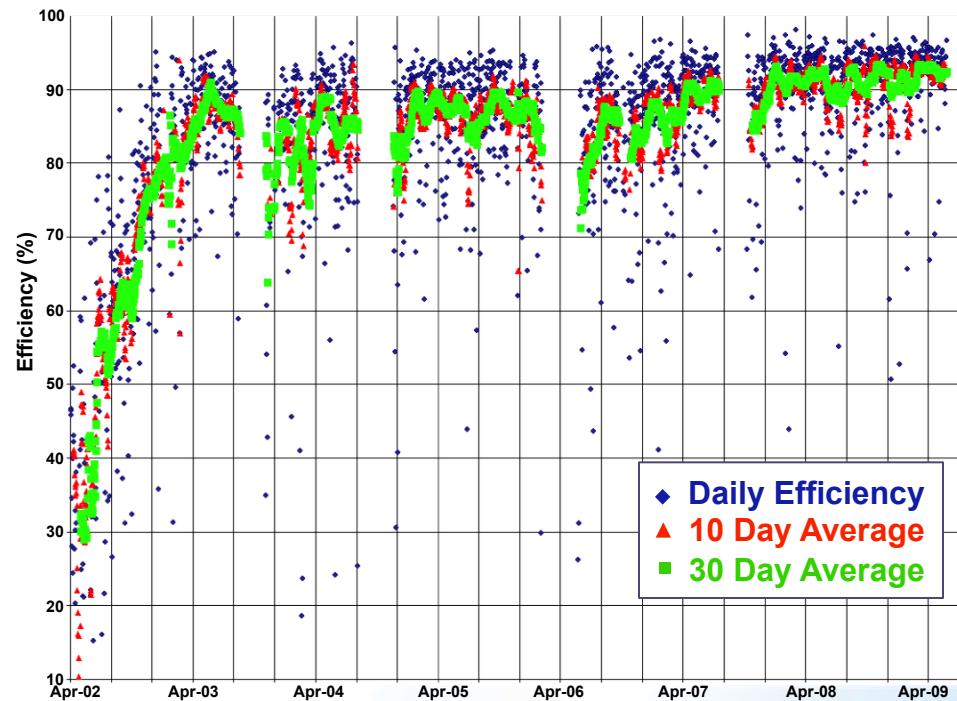
Run II Integrated Luminosity

19 April 2002 – 14 June 2009



Daily Data Taking Efficiency

19 April 2002 – 14 June 2009



❖ Tevatron Collider and DØ operating successfully in Run II

- Tevatron delivered $\int \mathcal{L} dt \rightarrow 6.9 \text{ fb}^{-1}$ of data: DØ recorded 6.1 fb^{-1}
- up to 5.0 fb^{-1} [Run IIa & Run IIb] dataset used in DØ analyses reported thus far

❖ Projections through end-FY10: expect to collect $\sim 9 \text{ fb}^{-1}$ data

❖ Stable operations at DØ with recent $\sim 92\%$ data taking efficiency

- excellent performance due to dedicated 24/7 effort from shifters & detector experts
 - BNL-DØ expert roles in Preshower and Luminosity Monitor subsystems
 - shift contributions include Captain, Tracking/Preshower, SAM database

❖ FY09 BNL-DØ members

- A. Patwa (100%), M. Begel (20%), S. Snyder (15%), S. Protopopescu (15%), K.Yip (15%, not in core program)
 - total 1.65 FTEs (1.5 in core program)
 - continue transition to ATLAS while maintaining needed role on DØ
- A. Evdokimov: BNL guest appointment
 - DØ effort shared between FNAL (25%) and BNL (25%)
 - resident at Fermilab

❖ Past Year Service Contributions

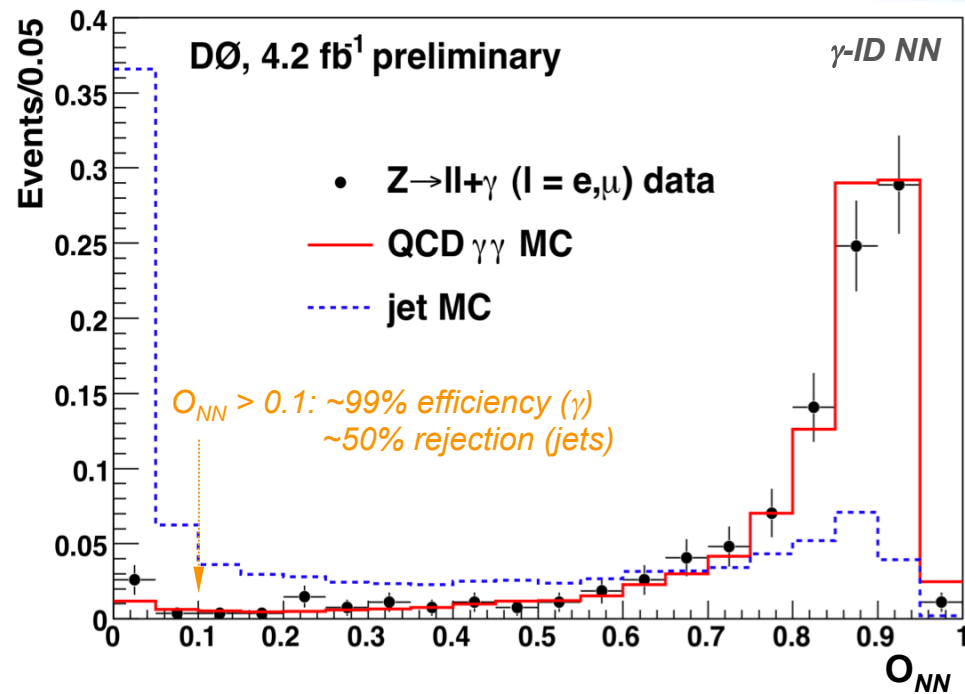
- Central and Forward Preshowers (CPS, FPS) hardware and software maintenance — A. Evdokimov: CPS and FPS, A. Patwa: FPS
- τ -ID Algorithm Group Co-convenor — A. Patwa
- Online and Offline Software support — S. Snyder
- Shift responsibilities — A. Patwa & S. Snyder (*Captains*)
A. Evdokimov (*Central Tracker and Preshowers*)
S. Protopopescu & K.Yip (*SAM database*)

❖ Physics

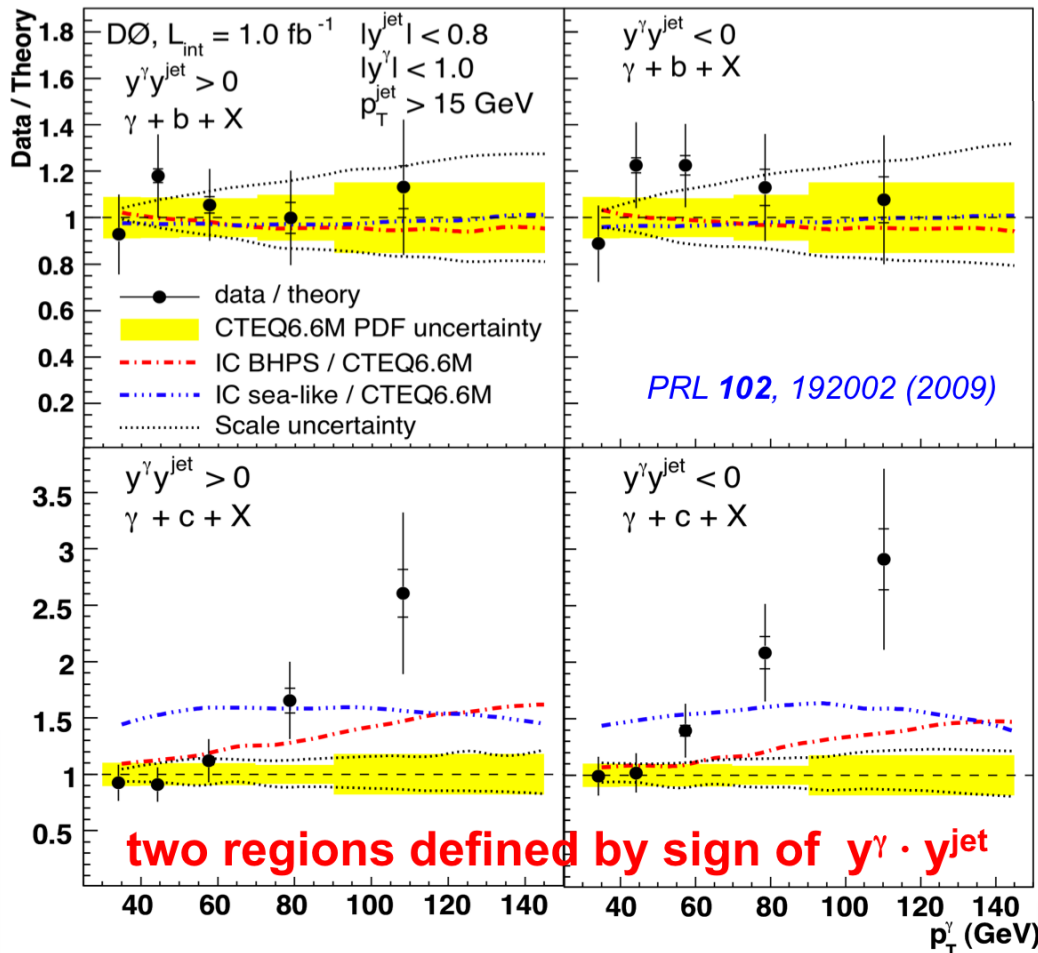
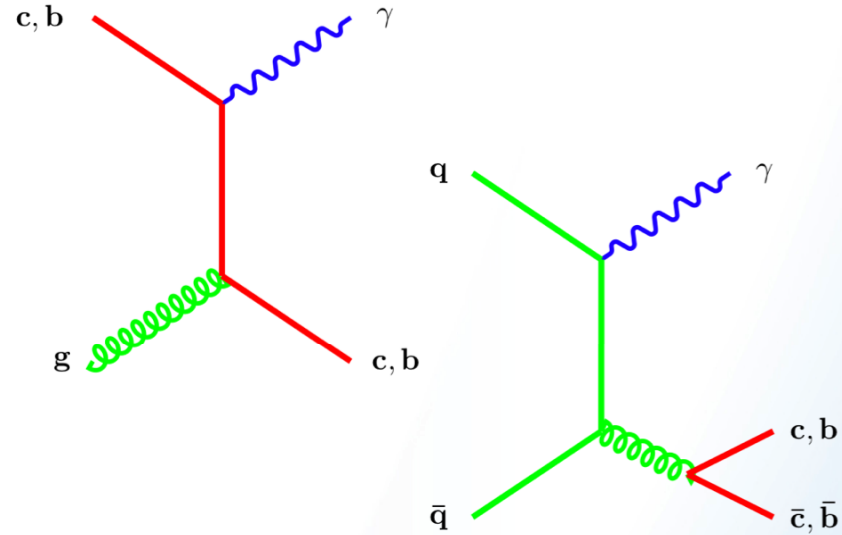
- Search for MSSM Higgs Boson in $H \rightarrow \tau\tau$ channel
 - A. Patwa
 - * as of Sept. 2009 appointed Beyond Standard Model (BSM) Higgs group convener
- QCD and Top Cross Section Measurements
 - M. Begel
- Model Independent Search for New Physics at high- p_T
 - S. Protopopescu
- Membership in Editorial Boards
 - Top Mass
 - * S. Protopopescu⁽⁺⁾, S. Snyder, M. Pleier⁽⁺⁺⁾ and A. Patwa
 - Inclusive Jet and High- p_T Jet Production
 - * M. Begel⁽⁺⁾
 - Jet Energy Scale Certification Board
 - * M. Begel
 - New Phenomena & Low Mass SM Higgs Searches with Heavy-flavor Jets
 - * A. Patwa

⁽⁺⁾EB Chair til August 2008; still member⁽⁺⁺⁾Joined BNL staff August 2009

- ❖ **Effort on improving performance of preshowers and inclusion into event selections for physics analyses**
 - e.g., implement energy-weighted width of CPS in Neural Net (O_{NN}) for e- or γ -ID
 - exploit fact that preshower width narrower for photons than for jets
 - addition of CPS: achieve $\sim 15\%$ improvement at high- p_T
 - analyses with CPS selections include
 - $H \rightarrow \gamma\gamma$, SUSY di-photon searches, QCD γ + jet measurements...
- ❖ **FPS**
 - past year, completed calibration with Run IIb upgraded AFE-II boards, which restored full dynamic range
 - future plans coordinated by A. Evdokimov include
 - development of e/ γ -ID in End-Calorimeter region using FPS
 - improvement of EM resolution at forward rapidities
 - similar inclusion into physics analyses



- ❖ Heavy-flavor content of proton can be probed in $\gamma + \text{jet}$ events where the jets are flavor tagged
- ❖ **M. Begel** initiated analysis
 - based upon earlier inclusive photon and $\gamma + \text{jet}$ measurements



- ❖ **NLO perturbative QCD (pQCD)** agrees with $\gamma + b$ jet measurements, but $\gamma + c$ jet data exceeds expectations at high p_T

- **Vogelsang** (BNL) contributed to NLO pQCD

- ❖ **Published 1.0 fb⁻¹ result**

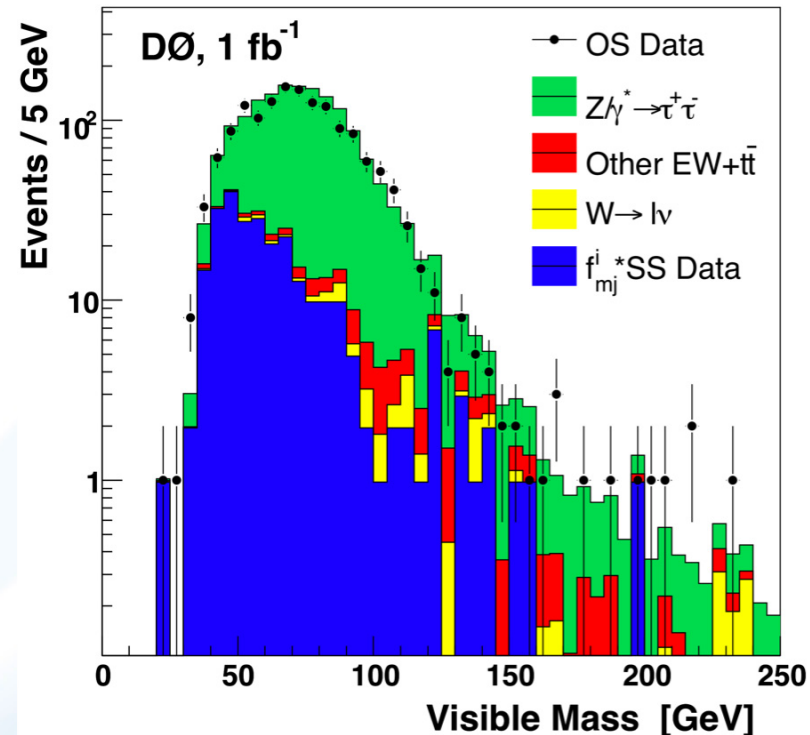
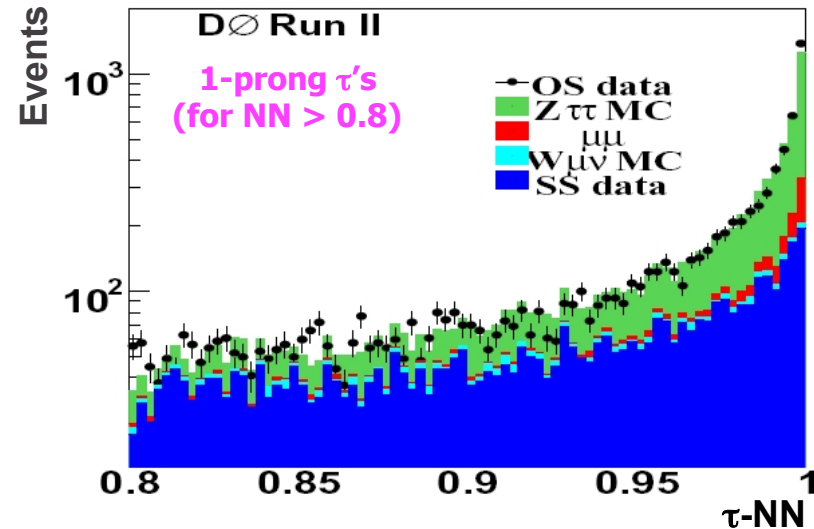
- PRL 102, 192002 (2009)
- expect to shed more light on $\gamma + c$ p_T distribution with full dataset

❖ **Published $Z \rightarrow \tau\tau$ cross section**

- PRD 71, 072004 (2005): 226 pb^{-1}
 - benchmark study for testing and certifying τ -ID algorithm based on NN
- PLB 670, 292 (2009): 1.0 fb^{-1}
- S. Protopopescu, A. Patwa have led τ -ID development and coordination efforts

❖ **$\sigma(p\bar{p} \rightarrow Z + X) \times \text{Br}(Z \rightarrow \tau^+ \tau^-)$**

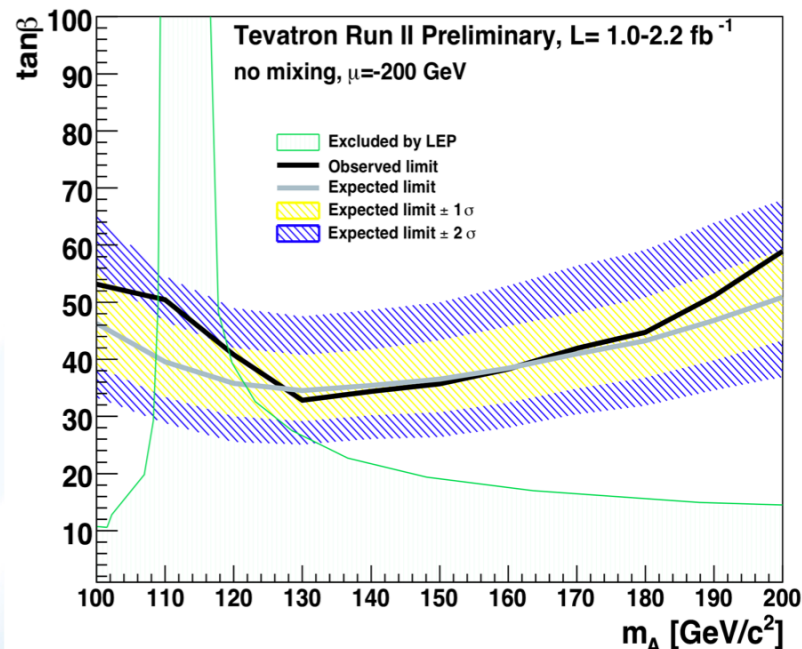
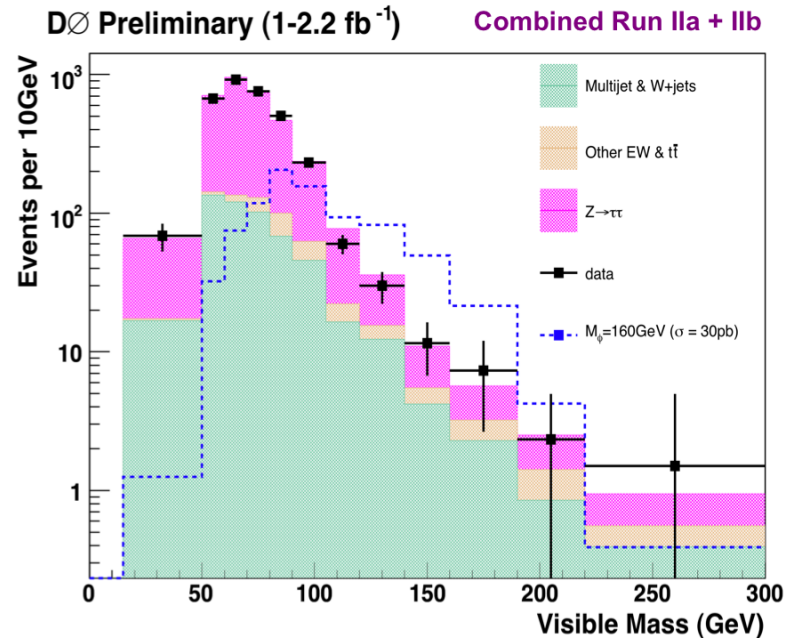
- PRD: $237 \pm 15 (\text{stat}) \pm 18 (\text{sys}) \pm 15 (\text{lum}) \text{ pb}$
- PLB: $240 \pm 8 (\text{stat}) \pm 12 (\text{sys}) \pm 15 (\text{lum}) \text{ pb}$
- SM theory (NNLO): $241.6^{+3.6}_{-3.2} \text{ pb}$

❖ **Methods developed for $Z \rightarrow \tau\tau$ have been extended to other τ -based physics analyses**



MSSM Higgs: Inclusive $\tau\tau$ Search

- ❖ **Result using 1.0 fb⁻¹ dataset for $\tau_\mu\tau_h$, $\tau_e\tau_h$, and $\tau_e\tau_\mu$: PRL 101, 071804 (2008)**
- ❖ **Updated 2.2 fb⁻¹ result considers $\tau_\mu\tau_h$**
 - isolated μ separated from τ : opposite sign
 - τ -ID NN discriminates hadronic τ from jets
- ❖ **No excess in data across visible mass spectrum**
 - exclusion limits in MSSM (M_A , $\tan\beta$) plane
 - Dawson, Kilgore (BNL) contributed to theory
- ❖ **New Tevatron (DØ, CDF) combination for $\tau\tau$ search channels**
 - with a fraction of final dataset, probing interesting region of $\tan\beta \sim 33$ [$\mathcal{O}(M_{\text{top}}/M_b)$]
 - most stringent limits on $\tan\beta$
- ❖ **In publication mode with 5.1 fb⁻¹ data**
 - A. Patwa to continue with Saclay group on search efforts with 7-9 fb⁻¹ data
 - aim for observation or reach sensitivity of $\tan\beta \sim 20$ for low M_A

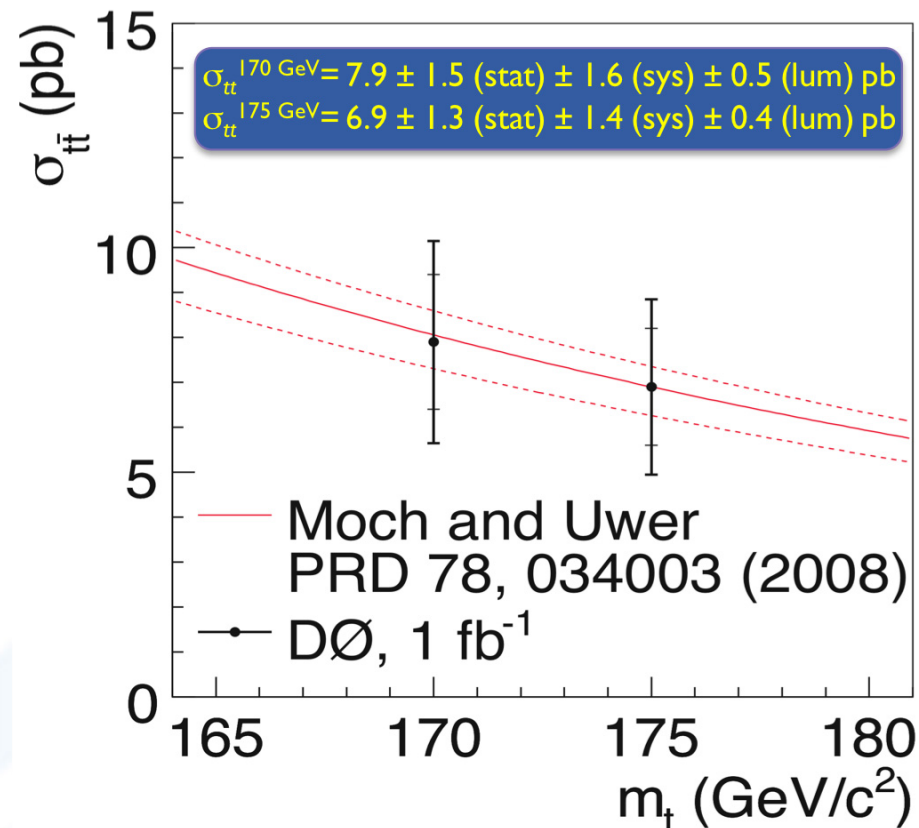
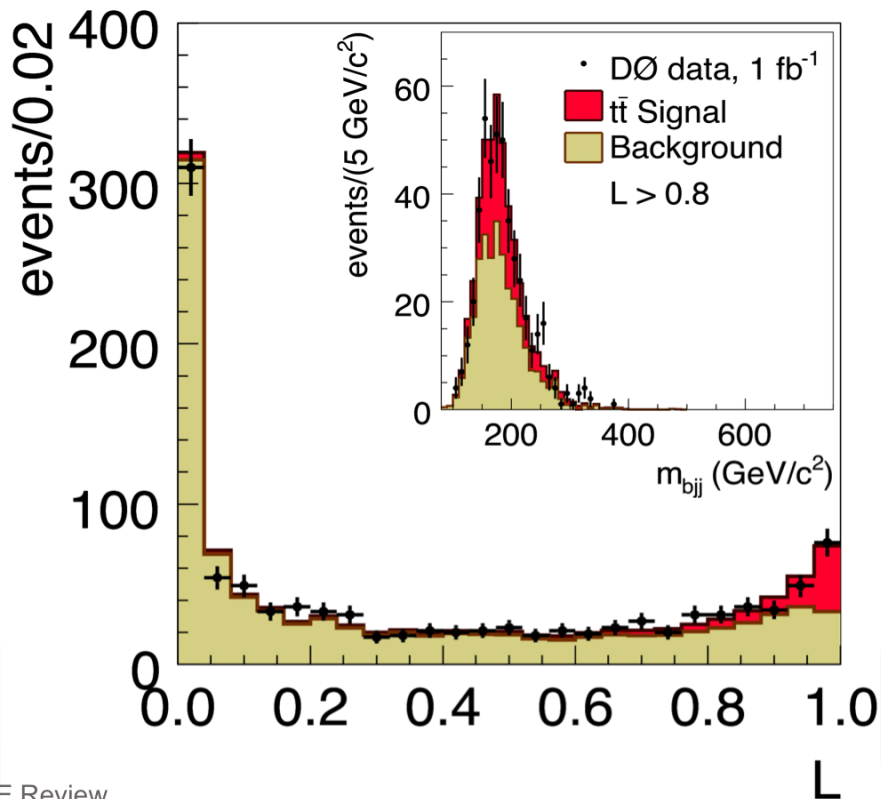
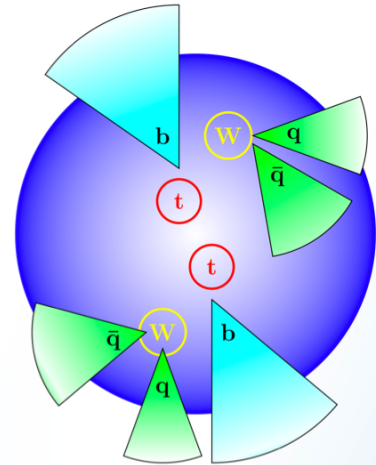


❖ $t\bar{t}$ production in all hadronic channel

- M. Begel leads effort
- 1.0 fb^{-1} publication in final stages of review

❖ Challenging signal-to-background

- six-jet background sample taken from data (S:B of 1:1300)
- signal enhanced by requiring two b-tagged jets (S:B of 1:50)
- suppress background by requiring four high- p_T jets (S:B of 1:7)
- extract signal via topological likelihood



❖ Measurements of differential cross section in $t\bar{t}$ system

- important test of pQCD for heavy quark production
- can constrain potential physics beyond standard model

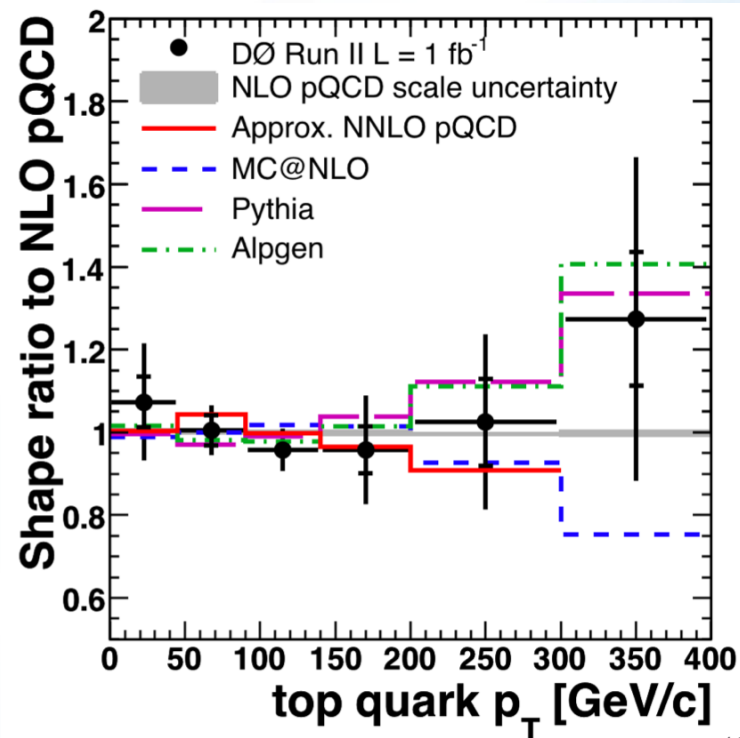
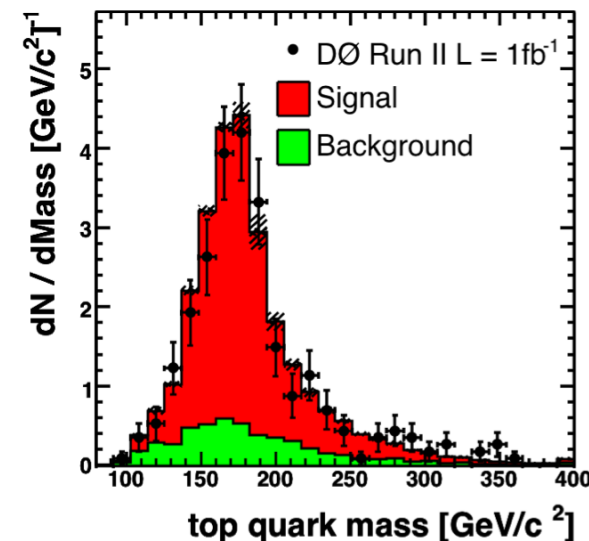
❖ 1.0 fb⁻¹ publication led by M. Begel: in final stages of review

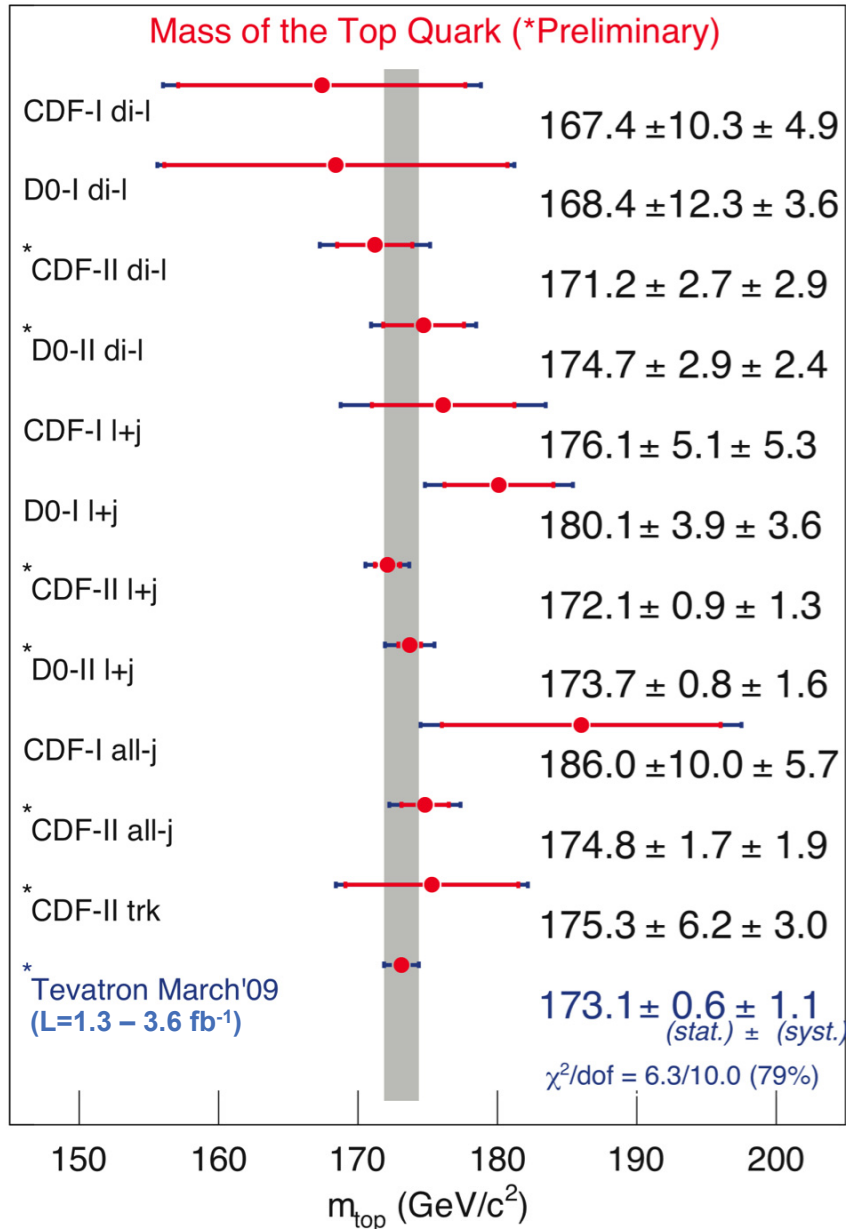
- data sample and selections based on inclusive $t\bar{t} \rightarrow \ell + \text{jets}$ cross section measurement
- uses constrained kinematic fit developed by S. Snyder to assign ℓ and jets with $t\bar{t}$ -pairs

❖ compare shape of measured differential cross section ($1/\sigma d\sigma/dp_T$) with expectation from NLO pQCD

- also compare with approximate NNLO pQCD calculation and several event generator
- Dawson (BNL) contributed to NLO pQCD

❖ all calculations currently reproduce the measured shape in data





❖ Editorial Board

- strong contribution from BNL physicists in reviewing precision measurements of top mass

❖ Measurements of m_{top} from different decay channels and using different methods yield consistent results

❖ Single experiment's top quark mass precision reaching 1 GeV

- efforts on reducing systematic uncertainties

$$m_{\text{top}}(\text{Tevatron}) = 173.1 \pm 0.6 (\text{stat}) \pm 1.1 (\text{sys}) \text{ GeV}$$



- ❖ **Tevatron and DØ detector performing well**
 - expect ~ 10 (12) fb^{-1} of Tevatron delivered data by end-FY10 (FY11)
- ❖ **BNL service contributions in preshower detector maintenance, τ -ID, and software and infrastructure support**
- ❖ **Strong focus on Higgs and top physics analyses at DØ**
 - searches for MSSM Higgs in di-tau final states
 - top quark cross section and mass measurements
- ❖ **Maintaining expertise on DØ while transition to ATLAS continues... FY10 plan for DØ effort includes**
 - MSSM Higgs search with 9 fb^{-1} data and leadership in BSM Higgs and τ -ID groups
 - continue necessary expert-level roles and software support for DØ operations
 - membership in Editorial Boards
 - Top mass
 - QCD jet production
 - NP and low mass SM Higgs to HF jets

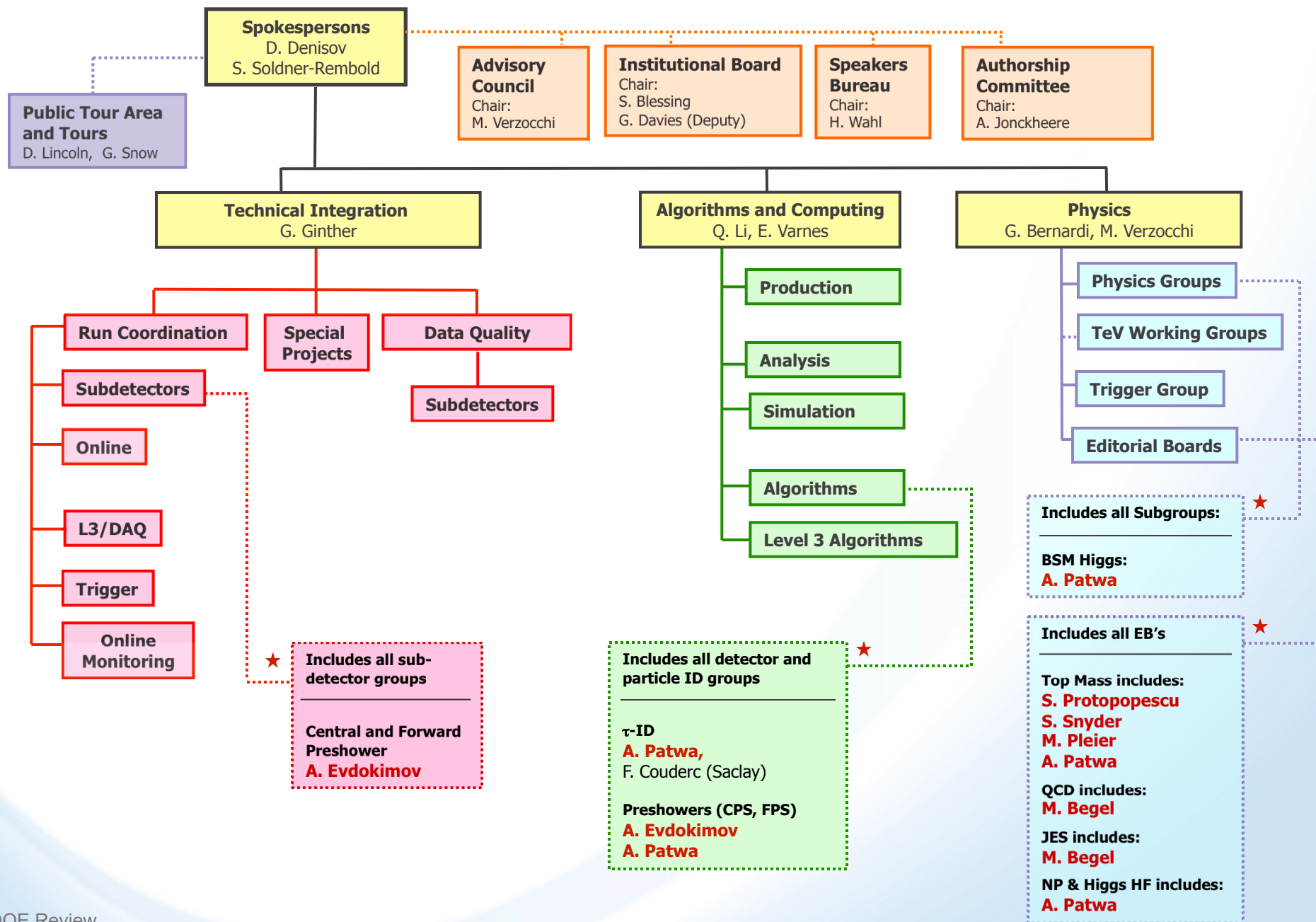
Fiscal Year	FTE on DØ (core program)
2007	2.7
2008	2.0
2009	1.5
2010	1.35
2011 (?)	0.9



Reference Slides



DO Organization and BNL





❖ Focus on leptonic final states and scan for significant deviations from SM

- **S. Protopescu** a primary contributor to MIS for new physics
- strategy based on dividing data into 7 non-overlapping, inclusive final states
 - defined according to high- p_T objects: $e, \mu, \tau, \gamma, \text{jets}, b\text{-jet}, \cancel{E}_T$
- check ‘shape’ and ‘number of events’
 - use KS-probabilities
 - normalization from fits to basic histograms:
 $p_T, \eta, \phi, \cancel{E}_T, M(\text{all combinations}), \Delta R$

❖ Final states are input to two algorithms

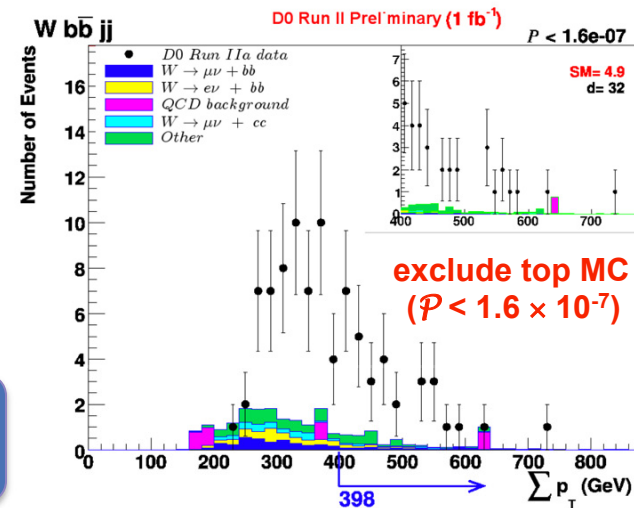
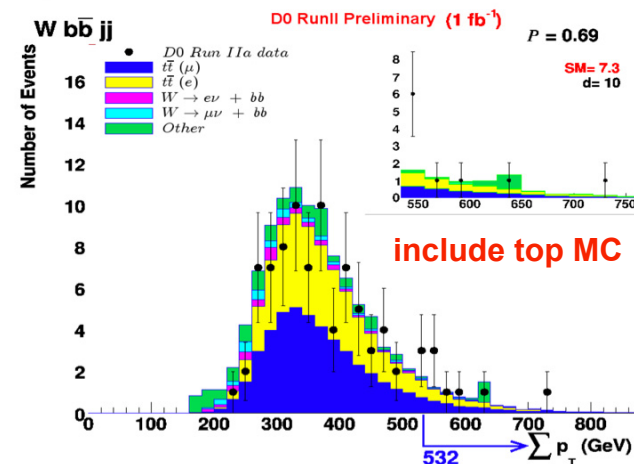
- **VISTA**: cycle through histograms for exclusive final states to check data vs. SM backgrounds
- **Sleuth**: search for excess in tails of Σp_T
 - test validity of “method” by sensitivity tests
 - e.g., with and without $t\bar{t}$ -pairs \Rightarrow “rediscover” top

❖ Results with 1 fb^{-1}

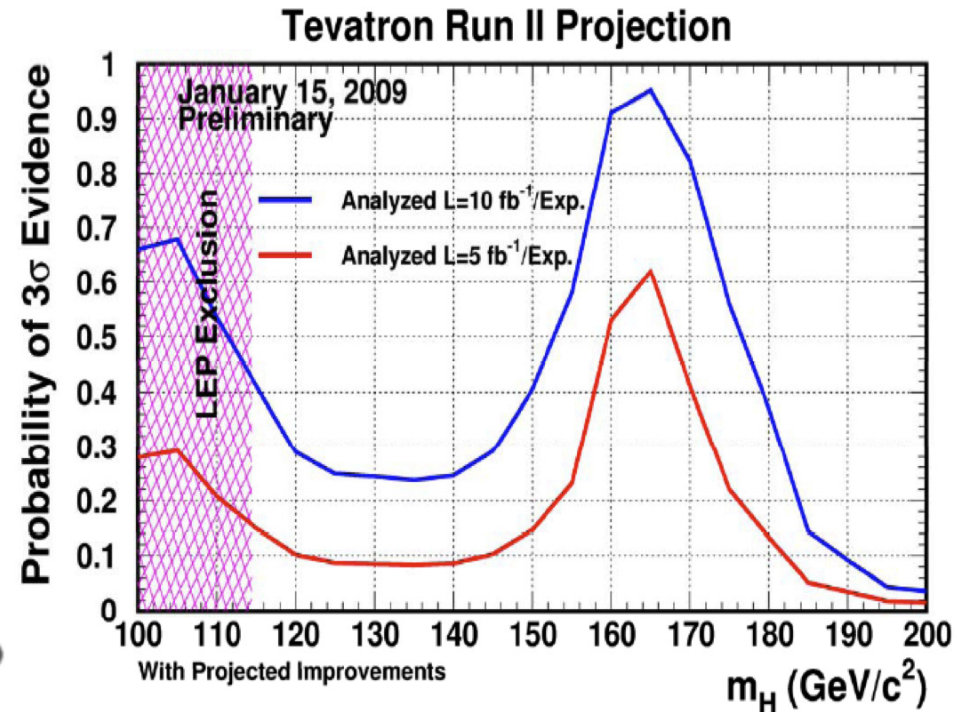
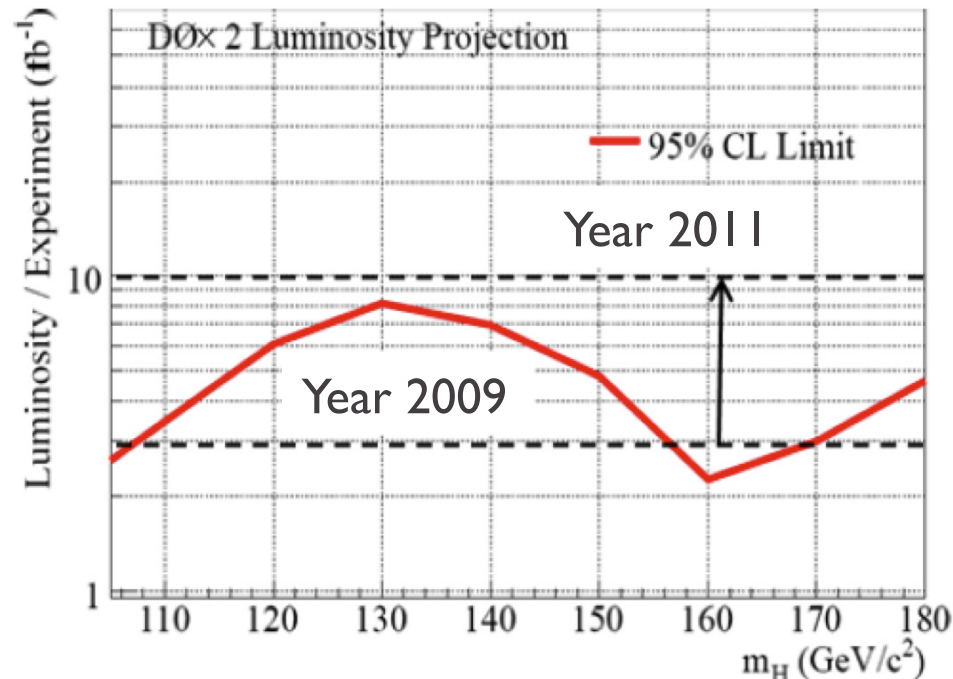
- **VISTA**: 4 out of 180 exclusive final states yield statistically significant ($\sim 3\sigma$) discrepancy
 - all point to known modeling difficulties
- **Sleuth**: one discrepancy related to μ resolution model

No hints yet... expect increased sensitivity from modeling improvements and $> \times 6$ collected data

$t\bar{t}$ -Sensitivity Test (Sleuth):



assume CDF + DØ, and analysis improvements underway



Tevatron Expected Higgs Sensitivity:
 ≥ 2011 – direct exclusion from
 115 to 185 GeV; or 1st evidence?

Probability of 3σ evidence in 2011:
 $> 40\%$ probability for
 $m_H = 115 \text{ GeV}$ with $L = 10 \text{ fb}^{-1}$